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# Defining And Clarifying The Problem

## Lecture 5 – Capstone

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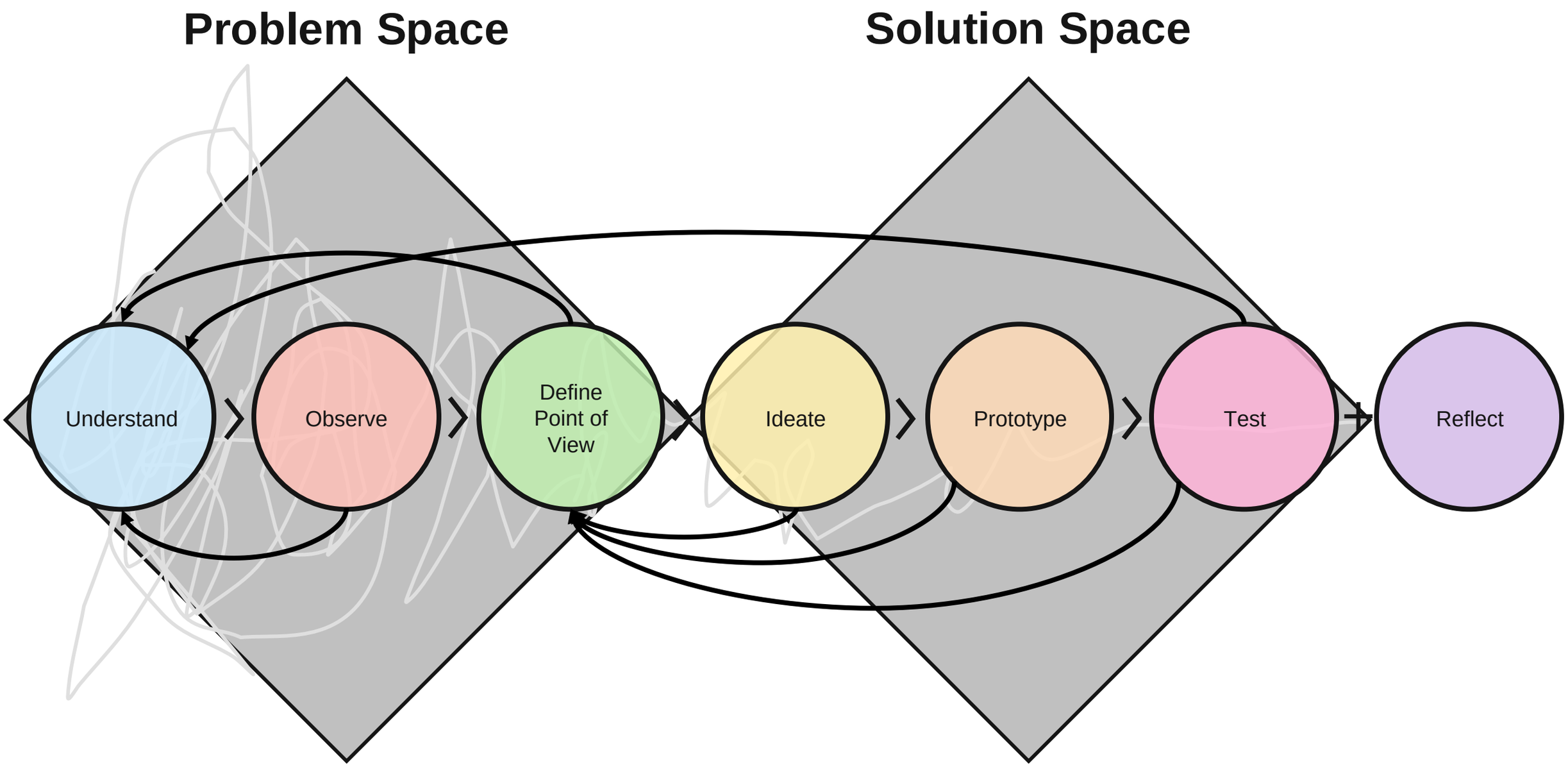
# Design Thinking Process

## From Problem to Solution



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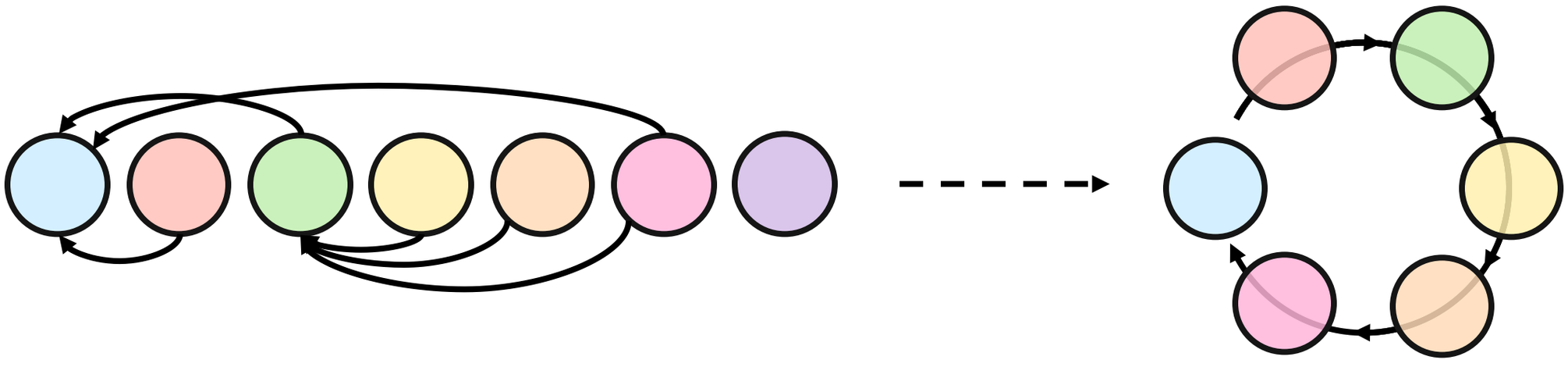
# Design Thinking Process

## Iteration on Iteration

- We can imagine this design thinking process to recur over and over again as we continue to explore the problem space and solution space.
  - **Convergence:** Narrowing the range of possible ideas and/or solutions through comparison, validation, and testing.
  - **Divergence:** Expanding the range of possible ideas and/or solutions through empathy, observation, and testing.



- Remember, we should always be **reflecting** throughout the design process.



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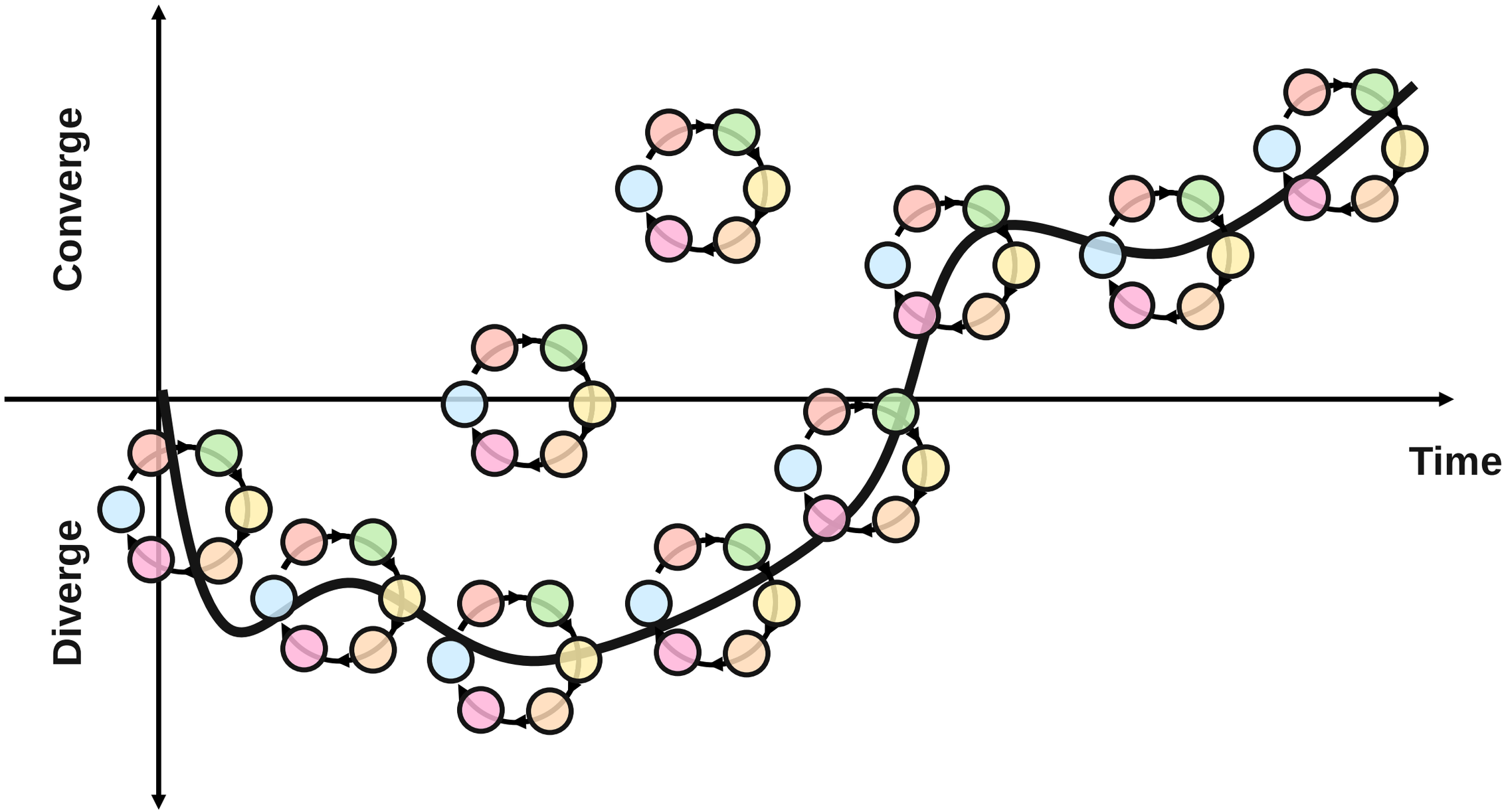
# Design Thinking Process

## From Problem to Solution



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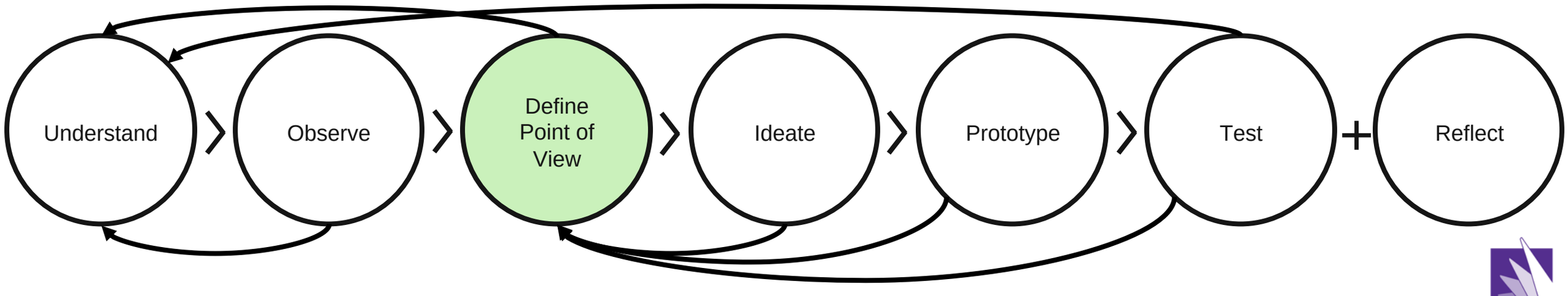
# Defining The Problem

## Finding the Focus to Address Customer Needs

- Understanding customer needs and observing relevant context provides the necessary information to begin defining the problem
- This includes the following tasks…
  - Defining a problem statement
  - Developing design requirements
  - Decomposing the problem
- Problems may need to be re-defined again and again based on knowledge gained from other aspects of design thinking

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# Problem Statement

## The Foundation of Design

- **Problem Statement**: a clear and concise statement about the design objective.
- Why should you write one?
  - Provides a focus for the design process. You can always come back and ask if your decisions are in service to the problem statement.
- How is this related to customer needs?
  - It is a higher-level abstraction of your customer needs. It lacks the details but captures the essence.
- Can it be changed?
  - Nothing is true, everything is permitted.

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# Problem Definition Tools

## What to do with a problem statement?

- Get feedback from stakeholders
  - Incorporate feedback and update problem statement as needed.
  - Be sure to not leave out any stakeholder groups!
- Generate requirements
  - Requirements should be specific.
  - Translation of problem statement into tangible goals.
- Identify different aspects of the problem
  - Affinity Diagrams
  - Fishbone Diagrams

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# Problem Definition Tools

## Design Requirements

- **Requirements:** statements that help identify, materialize, and document the detailed aspects of a problem.
- For them to be useful, requirements must be…
  - Justified: must be context relevant and supported by stakeholders.
  - Singular: must only address one issue.
  - Unique: avoid duplicate requirements about the same issue.
  - Testable: must be able to demonstrate if/how the solution address this requirement.
- **Requirements document**: a list of requirements that represents the design problem within a given context for a given set of stakeholders.

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# Problem Definition Tools

## Writing Requirements

- The design must cool the spliced o-rings in less than or equal to 3 minutes

- **Subject:** the thing that is being required to do or have this property
  - (The design)
    - The subject starts vague but evolves with the increasing specificity of the solution (system, sub-system, assembly, sub-assembly, part, feature, parameter, …)
- **Modality:** criticality of the requirement
  - (must)
  - Typically, constraints are framed as “must” while the criteria are framed as “should”; however, other conventions may be used.

# Problem Definition Tools

## Writing Requirements

- The design must cool the spliced o-rings in less than or equal to 3 minutes
- **Verb:** the action (if functional) or possession/being (if non-functional)
  - (cool)
    - Evolution of projects:  early Functional Requirements (FR)/Non-Functional Requirements (NFR) > late FR/NFR
- **Object:** the thing being modified or the property sought
  - (the spliced o-rings)
- **Adjuncts:** the modifiers to the verb (describe time, place, extent, manner)
  - (in less than or equal to 3 minutes)

# Requirements: In Class Activity

**Evaluate the following requirements. Explain why you think they are good or bad.**

- The user input block should be located in the top third of the screen.
- The design must be safe.
- The wind turbine blade hub must be mounted at least 300m above sea level.
- All corners and edges of the bracket must have rounded surfaces.
- Minimize power usage.
- The module must be able to process FLAC coded audio input.
- Per unit production cost is less than 30% of the sales price.
- Monkeys must eat at least 7 bananas every day.

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# Problem Definition Tools

## Sources of Requirements

- Design requirements come from a variety of sources including users, customers, designers, manufacturers, governing bodies, trade organizations, etc.
- These can be grouped into three primary sources.
  - Stakeholders: this includes users, customers, manufacturing/production, logistics, entities affected by the product, product disposal, and more.
  - Codes and Standards: codes are set by governing bodes and are legally binding, whereas standards are set by trade and non-profit organizations and therefore optional.
  - Design Process: new requirements are often discovered during idea generation, prototyping, and testing.

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# Problem Definition Tools

## Generating Requirements

- Requirements Checklists
  - A requirements checklist can be used to ensure sufficient coverage of requirements.
  - The checklist may need to be amended or modified depending on the domain/context of the problem.
- Objective Trees
  - A hierarchical model of requirements can be used to go from abstract concepts to detailed requirements.
  - Objective Graphs can show cross dependencies between requirements.

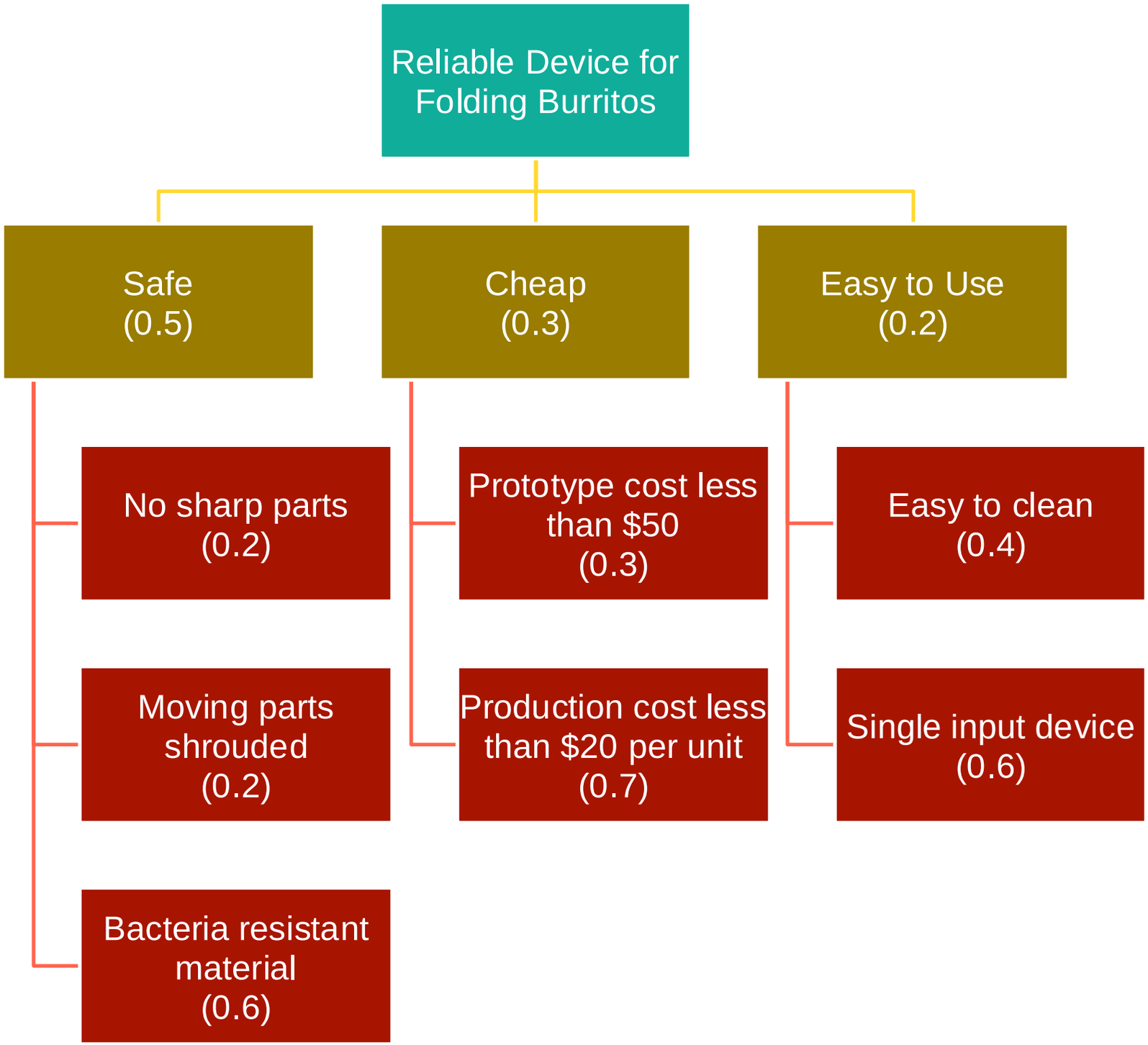
# Requirements Checklist

## Example used in household appliance design

- **Geometry**: Size, height, breadth, length, diameter, space requirement, footprint
- **Kinematics**: Type of motion, direction of motion, velocity, acceleration
- **Forces**: Direction, magnitude, frequency, weight, load, stiffness, deformation
- **Energy**: Output, efficiency, loss, friction, temperature, pressure
- **Material**: Physical properties, chemical properties, prescribed materials (food processing)
- **Signals**: Inputs, outputs, form, display, control equipment
- **Safety**: Manufacturer, environmental, operator
- **Ergonomics**: Man-machine relationship, aesthetics
- **Production**: Factory limits, production methods, achievable tolerances
- **Quality control**: Testing, measurement, special regulations and standards
- **Assembly**: Installation, siting, foundation
- **Transport**: Lifting gear, clearance, means of transport
- **Operation**: Noise, wear, marketing area, destination
- **Maintenance**: Servicing intervals, inspection, exchange
- **Recycling**: Reuse, reprocessing, waste disposal
- **Costs**: Maximum manufacturing cost, tooling cost, investment and depreciation
- **Schedules**: End date of development, project planning and control

# Objective Tree

## Example for a burrito folding machine


Reliable Device for Folding Burritos
Safe (0.5)
Cheap (0.3)
Easy to Use (0.2)
No sharp parts (0.2)
Moving parts shrouded (0.2)
Bacteria resistant material (0.6)
Prototype cost less than $50 (0.3)
Production cost less than $20 per unit (0.7)
Easy to clean (0.4)
Single input device (0.6)

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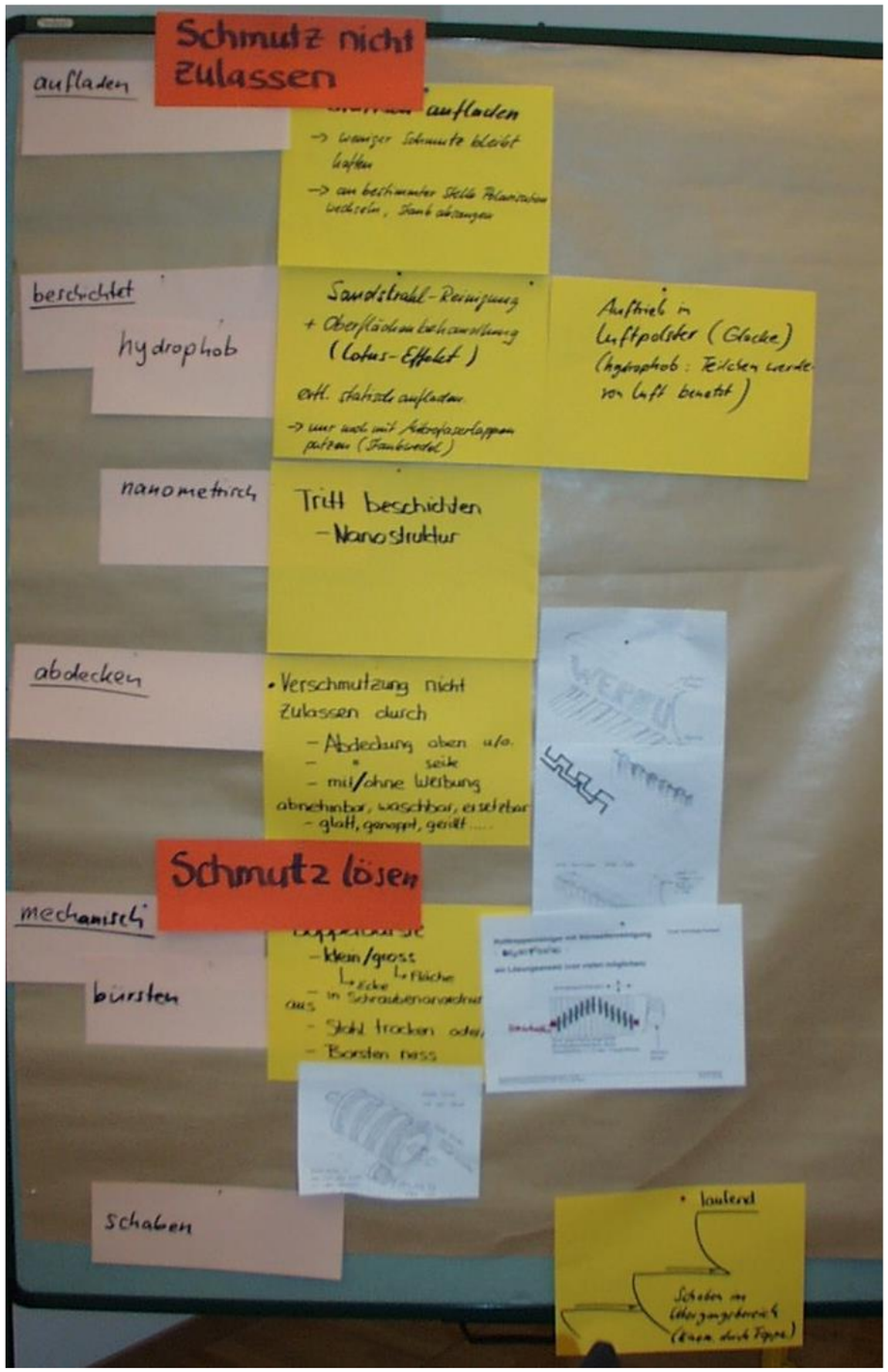
# Problem Definition Tools

## Affinity Diagram

- Process
  - Everyone writes “issues” on cards or Post-it notes (individually)
  - Share all these on a board/wall
  - Ask each person to move notes to similar “issues”
  - Repeat until “stable”
  - Evaluate the clusters to understand importance
- Rules
  - No talking until clusters are established
  - Keep descriptions brief

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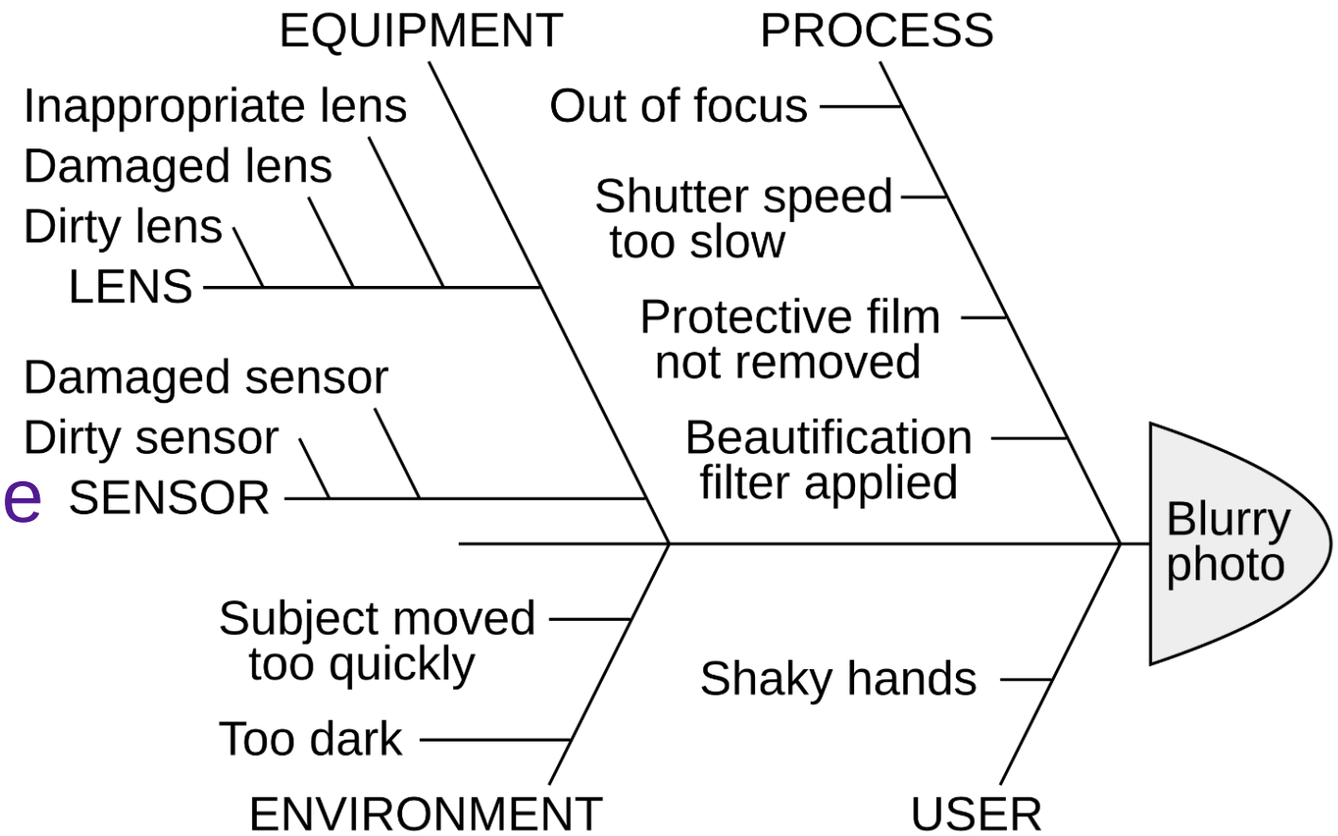
# Problem Definition Tools

## Fishbone Diagram / Ishikawa Diagram

- Fishbone diagrams are commonly used in root cause analysis for product quality assessment and control.
- The problem is labeled at the head of the fish, and the bones are primary, secondary, and tertiary causes for the problem.




- Let’s take a look at the example fishbone diagram.
  - Primary: process, user, equipment, environment
  - Secondary: out of focus, shaky hands, lens, too dark, etc.
  - Tertiary: damaged sensor, dirty lens, etc.

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# Problems Statements

## Good vs. Bad

- We need to build a new type of furnace that is better than what's currently available.
- How might we reduce the energy consumption of residential heating systems to improve efficiency and reduce costs for homeowners in cold climates?

- Extract 3 requirements from each problem statement.
- Decide which is a **good** problem statement and which is a **bad** problem statement.

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# Problem Statements

## Good vs. Bad

- We need to build a new type of furnace that is better than what's currently available.

1. **New Furnace Design**: The statement specifies the need for a new type of furnace.
2. **Improved Performance**: While vague, the use of the term "better" suggests that the new furnace should have some form of improved performance over current models.
3. **Comparison with Existing Models**: The requirement implies a need for benchmarks or criteria to compare the new furnace against existing models.

- How might we reduce the energy consumption of residential heating systems to improve efficiency and reduce costs for homeowners in cold climates?

1. **Energy Efficiency**: The solution must focus on reducing the energy consumption of heating systems.
2. **Cost Reduction**: The solution should lead to a reduction in costs for homeowners, including installation, maintenance, and operational costs.
3. **Applicability to Cold Climates**: The solution needs to be effective in cold climates. This requirement means that the solution should be capable of handling the specific challenges posed by cold weather.

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# References

## Questions?


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